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Humanizing Mathematics: The Humanistic Impression in the Course for Mathematics Teaching

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INTRODUCTION

What kind of contribution can education make in supplementing what takes place in the political arena so that future generations will be less prone to define their personal and national self- interest primarily in adversarial and military terms?

This article is based upon the assumption that education can make a difference. How much of a difference it can make and how long we will have to persist before we achieve results that are more than negligible is an issue of great concern. But we do need to make at least modest beginnings if there is any hope that we will not blow each other up in a worldwide effort to eradicate differences. As a beginning, we need to think of education in all areas from a more humanistic perspective.

My particular interest is with the subjects of mathematics, technology, and the natural sciences. In contemporary primary and secondary education they are, for the most part, presented as devoid of emotional, cultural, and humane values.

There are many reasons for concern over this amoral, ahistoric, and isolated conception of the scientific disciplines. Mathematics in particular is usually perceived by the public, and has generally been presented by teachers, as an area of knowledge characterized almost exclusively by facts and truths. What can be changed in the education of mathematics teachers that will enable them to participate in a more humanistic curriculum that acknowledges diversity?

Something of particular concern to this author is that this kind of narrow approach that does not refer to basic human values tends to ignore differences in students' religious and cultural backgrounds, as well as the traditional and cultural quality of the mathematical experience. Thus, the approach does not strive towards better understanding among students from different backgrounds, nor towards having them seek a common ground. Not only is there a total lack of connection with emotional and humane values that might enable students to appreciate their own and each others culture, but by ignoring the lengthy birth pangs of the evolution of ideas, this warped view of the scientific disciplines inaccurately portrays the nature of mathematical discovery itself.

Though in general, students are more diverse than we tend to acknowledge, I am concerned in particular with the differences among the students whom I teach, who come from two very different cultures. I teach in southern Israel, at Kaye College, a teachers' college that attracts both Jewish and Bedouin students. Kaye College was established in the 1950s as a teachers' seminary, and in 1982 was transformed into a college. Since the early 1970s, it has offered teacher training for all teaching tracks, including the Bedouin sector track. Efforts to attract Bedouin began three years ago, when the college designed a "Couples Project" course to address curricula that acknowledges the different cultures.

While formal education has been part of Jewish tradition for centuries, the nomadic Bedouin in this region first began sending their children to educational settings in 1948, when the State of Israel was established. Today, the majority of Israel's Bedouin have settled in permanent cities, towns, or villages and work in agriculture, construction, and education, among other fields, and the number of Bedouin students in higher education is constantly increasing. The Israeli government looks to education as means of Bedouins' integrating into Israeli society (Mofet, 2001; Ben-David, Y., 2001).

The students from both cultures come together in a course I have designed entitled "History of Mathematics and its Interlacing in Teaching Mathematics". They know very little about the development of mathematics, let alone the contributions each of their cultures has made to this development.

There is a need to address the question of what can be changed not only because of the specific cultural diversity I face with my own students, but because of cultural diversity throughout much of the world. By changing the basic principles of, and setting new goals for mathematics teaching, we can extricate ourselves from the discipline's silence on these vital matters. Teachers must be equipped with strategies for conveying mathematical knowledge that transcend skills for structuring logical foundations of scientific thought. Pupils must not only assimilate a concentration of logical phrases and ways of thought that underpin mathematical knowledge, but they must learn to do so through a process that reflects, at least to some extent, the historical ways by which humankind arrived at such knowledge.

HISTORICAL AND HUMAN PERSPECTIVES

The mathematical text, with its abundant symbols, poses numerous difficulties - even impossibilities - for many studying such a seemingly bland subject. For this reason, teaching ways of making the mathematical text come alive is of the utmost importance. One idea that has gained momentum in the past few decades is teaching mathematics through history.

Many researchers acknowledge the importance of history of mathematics in mathematics teaching and learning. Garner (1996), who reviewed the professional literature on the issue, concluded that "the study of history is essential for those who would attempt to teach mathematics." In a previous article, Garner (1995) claims that "students may be brought to a more meaningful understanding" of mathematics topics and "gain insight into how pure mathematics feeds applied mathematics in [which] seems abstract." According to Harakbi (1994), a "retrospective look at the historical development of mathematics allows the teacher to refresh and deepen both the understanding of a specific topic and didactic ways of presenting it. Engaging in the history of mathematics requires adoption of different points of view, including exposure to the obstacles and prohibitions mathematicians encountered on their way to glory. Therefore, experience in this area can be a factor in reducing anxiety about math" (Harakbi, 1994).

But history has much more to offer than merely revealing the steps through which an idea evolved - which itself can be viewed as yet another dry exposition to be absorbed. Educators often assume that there is no connection between the mathematical experience and emotional concomitants. In fact, emotional components are lacking at every turn in the development of mathematics and of personal and historical efforts to understand it. To remedy this situation, the study of an historical development of mathematics should not only reveal the evolution of ideas, but also investigate the emotional arena within which these ideas developed.

In a letter to his son, when the latter was on the verge of creating non-Euclidean geometry, Bolyai's father made a telling remark: "For God's sake, please give it up. Fear it no less than the sensual passion, because it too may take up all your time and deprive you of your health, peace of mind, and happiness in life" (Boyer, 1968). Yet Sizer (1984) wrote, "Learning is human activity, and depends absolutely on human idiosyncrasy." The latter statement is based on the idea that most prospective teachers do not begin their mathematical studies with human idiosyncrasy. Rather, it is obvious that the opposite is true. We must create an atmosphere and conditions in the classroom that are conducive to understanding, and teaching students to tolerate, what is different not only between two individuals from different cultures, but also between individuals who are apparently highly similar in say, two people from the same family.

The purpose of this paper is to show how a course in "History of Mathematics and its Interlacing in Teaching Mathematics" provides an opportunity for all involved to develop introspection about the nature of mathematics, while at the same time refreshing and strengthening the participants' espoused and non-espoused humanistic values. The paper examines how the history of mathematics can aid in the teaching of mathematics to students, in the following ways:

- Acknowledging the idiosyncratic world views of the mathematicians who developed the ideas

- Seeking an arena within which we can arrive at a better understanding of the emotional components in the development of mathematics

- Celebrating cultural diversity
- Intensifying a humanistic world view.

THE COURSE DESCRIPTION

A course such as the one we are discussing would traditionally be called "History of Mathematics," and this was the case at Kaye. However, some four years ago, the name of the course was changed to "History of Mathematics and its Interlacing in Teaching Mathematics," with the aim of emphasizing the humanistic aspect of mathematics teaching/learning. Along with the new course title came a new syllabus, which was constructed both to improve teachers' attitudes towards teaching mathematics and to expose them to diverse ways of learning mathematics.

The course participants are from two sectors: in-service teachers, ranging from novice to veteran, currently enrolled in a B.Ed program, and preservice mathematics teachers in their third year of college studies. Both groups include Jewish and Bedouin students. This diversity creates a rich opportunity for devising cooperative learning strategies in the classroom.

A discussion of the syllabus is held every year, at the beginning of the course; the discussion focuses on syllabus goals, content expectations, and terms. The discussion intensifies when course participants are informed that they will be: a) preparing teaching units during the school year; b) participating with each other in presentations; c) working in pairs or in threesomes; and d) becoming acquainted with the unit they will be preparing, which is to be included in a volume that is a compilation of their collective work over the year.

What usually occurs at this point is that the students, who have never met before, look each other over and openly or covertly seek out a partner. In this first lesson, the instructor does not dictate whom the students should choose. Later, should anyone seek advice, the instructor may make a suggestion. As for pairing up Bedouin and Jewish students, I direct the students to think crossculturally, aiming for at least some mixed pairs, in accordance with the integrated tone of Kaye College. It should be noted that although the preservice teachers are already accustomed to working in pairs during their studies, the in-service teachers may not be. Another issue is how to combine history content with mathematics content in the lesson set - that is, how to combine the science of symbols with the humanities when that science ostensibly negates any involvement with the humanities.

The first semester is devoted to familiarizing students with the chronological development of mathematics, reading and understanding texts from the history of mathematics, and attempting to make these texts more accessible to and appropriate for pupils by turning them into an integral part of the mathematics lesson. Most of the participants already have some knowledge of the better-known mathematicians and their discoveries.

I present the students with examples lesson plans compiled either by myself or by students of this course in previous years. These lesson plans give rise to intense, critical discussion, sometimes positive and sometimes negative. Often, comments such as "We'll do it differently" are heard; these comments indicate the teachers' caring and their desire to create a better product.

One lesson set, for example, is "Area: What is it?" This set has three sections, each focusing on a different sphere of the mathematics of area: geometry, geometric algebra, and algebra. Here, historical material is combined with mathematical material, and discussions of important personages in mathematics are set against solving mathematical problems (Katsap, 2000). Another example is "The Golden Section," which combines knowledge of ancient Greece, architecture, art, the works of Leonardo Da Vinci, and the beauty of nature. These elements touch on much of mathematics as well as on many humanistic areas in which mathematics plays an integral part. This first semester focuses on "classroom cohesiveness" and work in small groups. The students continually present the products of their small-group work to the class; later, these products will include units prepared by the students. This develops the students' openness and their desire to help other group members and to obtain help from them, and also fosters healthy competition and an orientation towards achievement.

At the mid-point of the first semester, the students are given guidelines for preparing their units, as follow:

- The selected unit topic is to be integrated into mathematical areas studied in school

- There is no restriction on historical eras

- Relevant areas from the history of mathematics can include: individuals who made a contribution to mathematics; mathematics problems; mathematical discoveries; and any historical material connected with mathematics

- The study unit may: a) combine an historical mathematical text with a mathematical topic relevant to teaching in the form of a complete lesson plan; or b) integrate a sequence of passages into lesson plans for the study of a particular chapter in mathematics in the school.

The variety of options offered the students in choosing a study unit makes the choice easier for them, and gives them a greater sense of independence and self-confidence. At the same time, however, it means that they must take responsibility and demonstrate competence, criticism, and autonomy in their decision-making. All this may sound familiar to instructors of teacher education courses, but again, combining a humanistic subject such as history with a scientific subject such as mathematics is somewhat unusual. After all, when have mathematics teachers had to struggle with the question of whether to present an historical tale to the pupils and allow them to discover mathematical elements in it, or to teach them mathematical laws (as is usually done), and then tell them about the life and times of the individual who discovered the laws? Or, if an interesting historical discovery does not fit in with the mathematics curriculum but the teacher finds it fascinating and wants to present it to the pupils, how should it be combined with the regular mathematics lesson? In cases, the teacher (i.e. the students in my course) must take responsibility and use his or her autonomy to make a decision.

Towards the end of the first semester, students choose partners, and a timetable for the students' second-semester presentations of the study units is drawn up. Each student pair begins the process of selecting a topic to be investigated, prepared, and presented to the class in a 45-minute presentation. Although this process is already familiar to the students from their previous studies, the innovation here is the manner in which the students repeatedly consult with each other before approaching the course instructor for help. Most of those who do consult with the instructor need help in choosing and organizing the material collected in their search, or in finding written and electronic information sources. The Internet plays a tremendous role in knowledge sources, and learning to use it is an additional learning skill that this course helps develop. Most of the topics and content chosen by the students are accepted.

Some of the students "try out" their study units first on their own pupils in the classes they currently teach. They then can tell their fellow course participants how the pupils responded. At the end of the unit presentation, a discussion, usually quite lively, is held in the course class; usually both constructive and negative criticism is offered. Often, there is a sense that the students say what they have to say for themselves more than for others, and give themselves tips for the future.

Not surprisingly, none of the lessons presented by the students in the second semester take the form of a lecture. They all involve group class activity, whether it be collaborative work, discussion, or drawing conclusions in groups and in full class discussions—providing a welcome experience in changing teaching methods and seeking diverse ways of improving teaching.

At the end of the second semester, after all work has been presented in the class, two students are chosen to compile the material on the computer and, together with me, edit the volume. These students reported that they found it very rewarding to process the separate study units presented during the course (to be discussed later) into a structured volume. The students also participate in discussions to determine topic classifications and to organize the study units accordingly. Each of the topics includes four to five units. Some of the titles that have come up in past courses are: Mathematics in Judaism and Islam; From Primitive Counting to Probability; Numerals, Numbers, and Sets of Numbers; Science, Art, and Craft; and Journey to the Roots of Geometry. The students claim that this work gives them a sense of contributing to the course's collective effort to promote advancement and innovation in mathematics teaching in the school. To date, four volumes have been published.

What is challenging in this course is the need for the instructor to flow with the class, never knowing what topics will be raised by the students during the year. This keeps the instructor on his or her toes, and stimulates the students' and the instructor's interest and curiosity. Together, the instructor and the students form a learning community requiring constant communication and cooperation. Friere sees such a situation as the ideal learning circumstances for liberating education, in which "teacher and pupils form a community of learners, and where both sides are essential factors in the process of obtaining knowledge" (Friere & Schor, 1990).

UNIQUE TOPICS

Some extremely interesting topics arose in this course following the students' extensive searching for knowledge sources. Before I compiled the course, I discovered the book Ayil Meshulash (Stature of the Triangle) (1960), written in the 19th century by a student of the Jewish Torah scholar the Vilna Gaon (Genius from Vilna). It was based upon notes found after the Gaon's death, that derived from his oral mathematics teaching. In this book, subtitled "On the wisdom of triangles and geometry and some rules of qualities and algebra," author Shmuel Lukenik notes that the Gaon was putting the notes and explanations in book form to preserve them for generations to come.

The Vilna Gaon, or Rabbi Eliyahu was a master of Torah, Talmud, Jewish philosophy, Halacha (Jewish religious law), and Kabbalah (Jewish mysticism). The bulk of his written work concerns corrections and emendations of Talmudic texts, and interpretations of the Shulchan Aruch (code of Jewish law). In the academic field, the Vilna Gaon wrote on geography (The Form of the Earth) and grammar (Eliyahu Grammar). He was also interested in music, claiming that most of the arguments of the Torah would be incomprehensible without it (On-line Resources, 2001). According to some sources, the Vilna Gaon is the author of "The Gaon's Theorem," a principle of the mathematics of infinity (Feldman, A., 1999). Other sources claimed that this theorem was called "Kramer's Theorem," Kramer being the Vilna Gaon's family name. Gerver (1993), however, stated that this supposition was unlikely, as the author of this article did not present proof for these two opinions.

After reading Ayil Meshulash, I had the idea of including in the course Jewish and Islamic sources of mathematics history and integrating them in mathematics teaching. The result was a collection of materials included in a chapter entitled "Mathematics in Judaism and Islam," unique to this course. Every year, a number of student pairs, both heterogeneous (Jewish and Bedouin) or homogeneous, work on this chapter.

Ayil Hameshulash was frequently chosen for investigation by these students, as it is both a mathematical work including mathematical explanations and geometrical definitions, theorems, and proofs as well as selected topics in algebra, and an historical document. Although the book was written 200 years ago, it still contains explanations that cannot be found today in any other mathematical work. The students in the course maintain that this book offers better explanations than those used today, and often say that they find it exciting to study such a venerable work. In one of the lectures, the students compared the Vilna Gaon's presentation of the right-angle triangle with that of Israeli mathematics teacher Benny Goren in his book Plane Geometry - a text currently in wide use in Israeli schools. Most of the students in the class announced that they would adopt the former method in teaching this topic in their classes.

CULTURAL DIVERSITY

Not surprisingly, homogeneous Jewish student pairs usually seek material on Jews who contributed to mathematics, as well as material found in the Torah, which is full of mathematics (the Jewish tradition of interest in studying mathematics comes from the Torah).

Homogeneous Bedouin pairs of students usually seek mathematical material authored by Arabs. It is interesting to note that the mathematicians they choose are often already familiar to them, but only as clerics or poets. As one of these is the Persian mathematician, astronomer, philosopher, physician, and poet commonly known as Omar Khayyam. Khayyam may be best known for The Rubaiyat, but his book Maqalatfi al-Jabr wa al-Muqabila is a masterpiece on algebra and is of great importance in the development of algebra.

The Bedouin students' discovery of so many significant mathematicians gives them a different view of mathematics, as well as greater pride in their people. In addition to their investigation of these individuals and their contributions to mathematics, the Bedouin students bring in Koranic writings, and all the students work on mathematical problems found therein—thus imbuing them with greater pride in their Arab heritage.

Investigating the Jewish and Arab mathematicians arouses a great deal of interest among the students participating in the course. As it is the first opportunity both the Bedouin and the Jewish students have to interpret the original mathematical language of the Vilna Gaon, in the ancient Rashi Hebrew of the time, as well as the mathematical language of the Arabic Koranic text. Thus, the students unwittingly acquire humanist values, such as respect for the history and tradition of their own and other peoples.

REFLECTIONS ON HUMANISTIC EDUCATION

What does it mean for education to be humanistic? This course enabled the instructor to come up with a number of tentative answers to this question. Brown (1996), who discussed humanistic mathematics education, claimed that first of all, there is a need to deepen the understanding of the perception of humanism and human nature, and their lengthy history. After that, interpretations of education should be studied in depth, along with the development of the humanistic perception. Finally, mathematics itself should be reassessed. In another article, Brown (1993) asks: "How might we use mathematics to convey knowledge and attitudes towards the world and about oneself that would be valuable in many non-mathematical contexts?"

As of this point, I am currently investigating in more than anecdotal way the implications of a course of this sort at Kaye College. Nevertheless, initial findings from the pilot study show that most of the students gained a different view of mathematics. This was indicated by their considerable appreciation and esteem for the value of the history of mathematics, and for its influence on their view of mathematics and mathematics teaching in the school. The students became more open to and more willing to accept knowledge accumulated through history that could be defined as a humanistic value - i.e. appreciation of the evolution of ideas of the many false starts that are part of the journey.

Another humanistic value mentioned by the students in the pilot study was respect for different cultures and appreciation for other eras. This may sound obvious for history or literature classes, but it is rare with regard to mathematics classes. The pilot study also found that the course gave the participants a sense of power, and taught them to deal with new challenges. The covert competition that developed between the student pairs in presenting their material forced them to invest time and effort in a search for interesting, creative material and to find diverse ways of presenting their topic—and also to keep trying. All this can be classified as the humanist value of self-actualization.

One of the most important comments that came up in almost every lesson, in one way or another, reflected the students' genuine desire to pass the torch to their own pupils, and to make them aware of what they themselves had learned and experienced. This was evident among both the experienced teachers and the preservice teachers, and was evidence of these teachers' caring and sensitivity towards their pupils. I often heard the teachers say, "Let's send them [the pupils] to find the material themselves"; "Let's let the pupils prepare and teach a lesson, so they can discover things on their own." This leads us to another humanistic value: expressing humanity and respect for others.

Finally, the students arrived at the material through self-discovery. The experience of searching for the material and familiarity with and use of knowledge sources not previously accessible led to a humanist value that they expressed both orally and in writing: showing intellectual interest.

CONCLUSION

Increasing teachers' awareness of the development of mathematical knowledge can help them fulfill their professional commitment, even narrowly construed as teaching pupils and instilling in them habits of scientific thought. Naturally, their pupils do not absorb only the knowledge; they undergo a learning process that reflects, in one way or another, the process experienced by humankind in attaining this mathematical knowledge.

Teachers' lack of knowledge - or their attitude of outright dismissal - when faced with the question "Why?"

can make pupils passive, indifferent, or even averse to mathematics. Instead, teachers can encourage pupils to ask, "Why do I do this?" or "How can I explore this?" Here, I do not refer to the knowledge of experts in the history of mathematics, as that knowledge is purely academic and has little to do with mathematics education in the school. I refer only to relevant topics and areas of mathematics that enrich mathematics teaching, thus enabling the mathematics teacher to foster an atmosphere allowing mind and emotion to take flight together. Since the dawn of civilization, wise men and women have advanced mathematical knowledge, and have also educated the younger generation in "the qualities of the whole person." Much of the teachings of Socrates, Plato, Aristotle, and many others are devoted to humanistic education. Among the principles of Platonic humanist perception, we find values such as "Worthless is the life of he who lives without investigation and a critical view of what is good," alongside, "The full measure of a man is in his wisdom and knowledge" (Aloni, 1998).

But for pupils today as well as for most teachers, Pythagoras's theorem is no more than $c^2 = a^2 + b^2$. Knowing that this theorem has been in existence across the world for over three thousand years, and how it has been proven in many different ways, may excite them and lead them to join the ranks of those who see the beauty behind the rigid and ostensibly inimical language of mathematics.Hersh (as cited in Brockmam, 2001) states:

> Mathematics is neither physical nor mental, it's social. It's part of culture, it's part of history, it's like law, like religion, like money, like all those very real things which are real only as part of collective human consciousness.

The latter statement may be made more obvious while, in the marvelous book Even-Zifer the Doctor, Sissa (1960) tells the 12th-century story of the friendship between a Jewish doctor from Cordoba and the Christian royal scribe from Hungary, a friendship based on the love shared by seekers of knowledge in the Dark Ages and drawing on the human spirit. Both were enamored of the enchanted science called mathematics. Sissa writes, "Is it possible to integrate science into a story? Is there not something amazing in the history of science, as surprising and as fascinating as the history of nations?"

It is no wonder, then, that the students in the course discovered another world within a subject so familiar to them. As they explored the depths of history, the students learned of the hieroglyphics in the Rind and Moscow papyruses, mathematical discoveries from ancient Greece through the Middle Ages, stories of charity from the Koran, and astronomical calculations for the Jewish calendar. In addition, they looked at modem mathematics and mathematicians such as Descartes, Euler, Gauss, and Lobadievsky.

It may be debatable whether there is a parallel between the historical development of mathematics and the process of clarifying values expressed by students participating in the course. But the contact between the two areas—mathematics and the history of mathematics—as well as appropriate training methods gave rise to positive humanistic energies and a new view of the subject that the students had chosen to teach. It is to be hoped that this learning added another aspect to their professional humanist development as teachers.

Today's focus on technological means cannot replace the crucial human figure of the teacher, who is responsible for fostering pupils' curiosity about mathematics—a curiosity rooted in human emotion. Teachers constantly face the challenge of renewing education and ways of learning in teaching mathematics in order, as Hook (1994) puts it, to shape teaching practice in our society "and [to] create new ways of knowing and different strategies for the sharing of knowledge."

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A Brief Look at Mathematics and Theology

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Such a really remarkable discovery. I wanted your opinion on it. You know the formula m over naught equals infinity, m being any positive number? [m/0 = ∞]. Well, why not reduce the equation to a simpler form by multiplying both sides by naught? In which case you have m equals infinity times naught [m = ∞ x 0]. That is to say, a positive number is the product of zero and infinity. Doesn't that demonstrate the creation of the Universe by an infinite power out of nothing? Doesn't it?

Aldous Huxley, *Point Counter Point*
(1928), Chapter XI

INTRODUCTION

We are living in a mathematical age. Our lives, from the personal to the communal, from the communal to the international, from the biological and physical to the economic and even to the ethical, are increasingly mathematicized. Despite this, the average person has little necessity to deal with the mathematics on a conscious level. Mathematics permeates our world, often in "chipified" form. According to some theologies, God also permeates our world; God is its origin, its ultimate power, and its ultimate reason. Therefore it is appropriate to inquire what, if anything, is the perceived relationship between mathematics and God; how, over the millennia, this perception has changed; and what are its consequences.

I begin with two stories. Recently, I spread the word quite among my mathematical friends that I had been invited to lecture on mathematics and theology. I wanted to get a reaction, perhaps even a suggestion or two.

One, a research mathematician, the chairman of his department, who, in his personal life would be considered very devout in a traditional religious sense, told me that, "God could never get tenure in our department."

Another friend, well versed in the history of mathematics, told me, "The relation between God and mathematics simply doesn't interest me."

I think that these two reactions sum up fairly well the attitude of today's professional mathematicians. Though both God and mathematics are everywhere, mathematicians tend towards agnosticism; or, if religion plays a role in their personal lives, it is kept in a